DOCUMENT RESUME

ED 057 539 40 EC 040 819

AUTHOR Wepman, Joseph M.; Morency, Anne S.
TITLE School Achievement as Related to Speech and Perceptual Handicaps. Final Report.
INSTITUTION Chicago Univ., Ill.
SPONS AGENCY Office of Education (DHEW), Washington, D.C. Bureau of Research.
BUREAU NO BR-7-0461
PUB DATE Jun 71
GRANT OEG-2-7-070461-4543
NOTE 52p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Academic Achievement; *Exceptional Child Research; *Intermediate Grades; Learning Disabilities; Longitudinal Studies; *Perceptual Development; *Perceptually Handicapped; Speech Handicaps

ABSTRACT

A longitudinal study of 120 children through grades one to six was undertaken. The present study focused on the intermediate grades (four through six). The goals were to explore the relationships among perceptual processing ability development, articulatory accuracy, intelligence, and academic achievement. The assessment battery consisted of an original five-part perceptual test battery; the Bender Visuo-Motor Gestalt test, the Dual Modality Test of Articulation, and the Metropolitan Achievement Test. The major findings of the study were that: the perceptual tests showed a yearly change characteristic of developmental processes; perceptual process ability and articulation errors became asymptotic by the end of the third grade; there was no discernible difference in articulation accuracy whether or not a child was exposed to speech therapy during the first three grades; there was a continuing effect upon school achievement of the level of perceptual processing ability at grade one; there was almost no discernible relationship between early articulation ability and school achievement at any grade level; and speech therapy did not enhance school achievement of those children who were exposed to it over those who were not. (Author)

ED057539

PA-40

Final Report
Project #70461
Contract #OEG-2-7-070461-4543

SCHOOL ACHIEVEMENT AS RELATED TO SPEECH AND PERCEPTUAL HANDICAPS

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Chicago, Illinois

June 1971

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Authors' Abstract

A longitudinal study of 120 children through grades 1-6 was undertaken. The present study was focussed on the upper grades (4, 5, 6). The goals were to explore the relationships between (1) perceptual processing ability development; (2) articulatory accuracy; (3) intelligence and (4) school achievement.

The assessment battery consisted of an original five-part perceptual test battery; the Bender Visuo-Motor Gestalt test, the Dual Modality Test of Articulation and the Metropolitan Achievement Test.

The major findings of the study are:

(1) The Perceptual Tests show a yearly change characteristic of developmental processes;
(2) Perceptual process ability and articulation errors become asymptotic by the end of the third grade;
(3) There is no discernible difference in articulation accuracy whether or not a child is exposed to speech therapy during the first three grades;
(4) There is a continuing effect upon school achievement of the level of perceptual processing ability at grade 1;
(5) There is almost no discernible relationship between early articulation ability and school achievement at any grade level;
(6) Speech therapy did not enhance the school achievement of those children who were exposed to it over those who were not.

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Preface & Acknowledgements

This report of a three-year longitudinal study and the related study of the same children for the preceding three years is the culmination of a practical application of a theoretical position developed over the years about children's learning. In brief, it was held that children come to the educational process of formal schooling differentially equipped with the developmental potentials for learning. Identifying these pre-cognitive processes and relating the individual differences to school achievement and to speech articulation has been the working goal of the study. Its contribution to a greater understanding of the learning process, its generalizability to all children from the sample studied and its significance in determining part of the nature of the cause underlying underachievement are hoped for conclusions.

Over the three-year span of the longitudinal study such as the present one many students and staff members of the Speech and Language Research Laboratory made significant contributions. Their work was duly appreciated. Dean Mitchell, Sara Klassen-Hass, Michael Nash, Mary Riege, Pat Mitchell, Sylvia Savit and Jeff Grip assisted in the administration and scoring of the test battery. The statistical analysis of the data was in consultation with Spencer Swinton. It is of some note that the first three contributors on this list completed their doctoral programs under the aegis of the Laboratory, while the next two obtained their M.A. degrees. The study is in many ways a product of their activities and served as an organizing point for additional research.

Our appreciation is likewise due to the staff, faculty, and children of the Community Consolidated School District #21, Cook County, Wheeling, Illinois who cooperated so completely throughout this study as they had in the previous one. It is most unusual to get such continuing cooperation in a school system over a six year span. Much of the credit for this is due to the interest and effort of Kenneth Gill, the Superintendent of the district, Richard E. Wynn, the Director of Research for the district, Norman Geske, the Director of Instruction and Mrs. Irene Shumak, the Coordinator of Speech Education.

Joseph M. Wepman, Ph.D.

Anne S. Morency, M.A.

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Introduction to Study

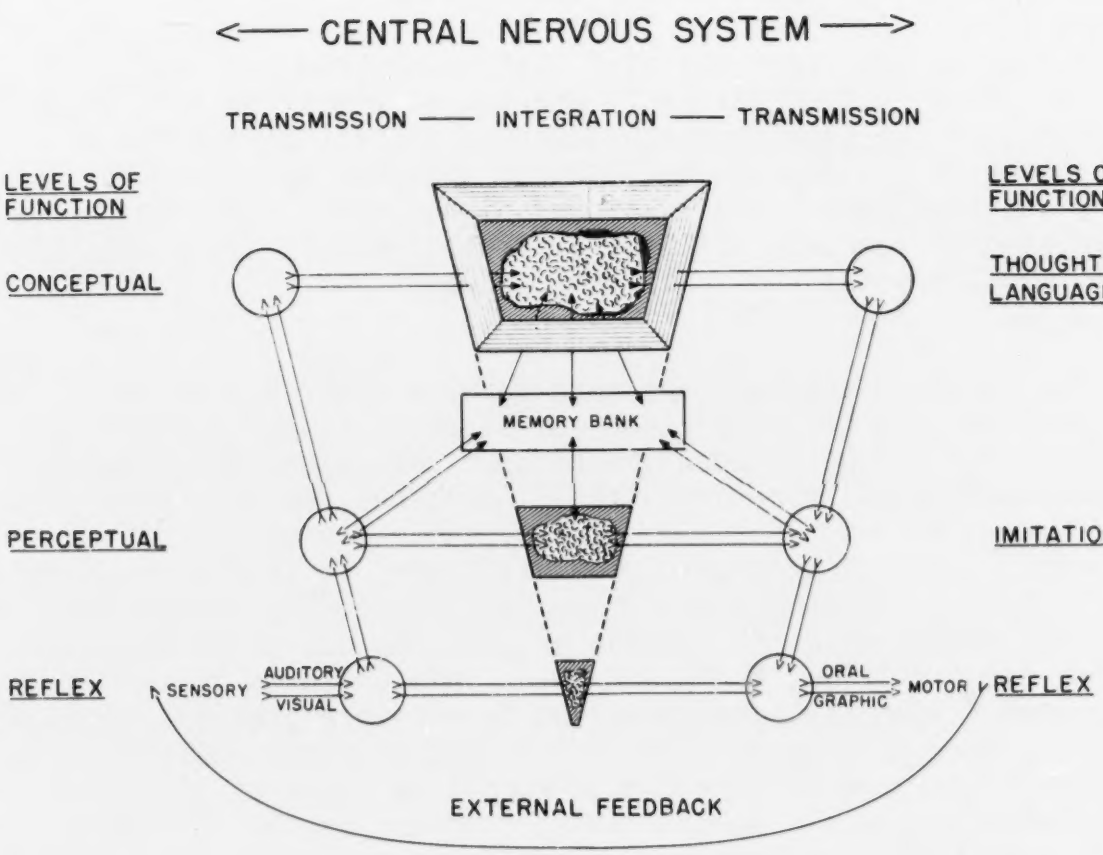
With heightened concern over children who are apparently underachieving in early elementary school has come a growing interest in special learning problems. This can be seen by the extent to which educational literature is currently reporting studies of such problems and the fact that in recent years an entire journal has been initiated that is devoted entirely to the field of learning disabilities. One of the immediate results of this trend can be seen in the broadening concept of individual differences in children to include, in addition to such parameters as intelligence and emotional disturbance, those which are related to language ability, articulation efficiency, motoric development, reading readiness and perceptual ability, to name only a few.

The present study was intended to be a contribution in this general area of inquiry and was directed toward an investigation of the influence upon learning of perceptual development. The problem, stated more practically, concerns the relevance of establishing the degree and mode of perceptual process development with a view to predicting the difficulty or ease with which a child is able to master his school subjects. The theoretical construct of the modality concept of learning was first proposed in 1960 (Wepman, 1960, 1964) and holds that children go through a stipulated predetermined progression from simple (reflex) behavior at birth, through a sensori-motor (perceptual) level of imitation and echoic behavior to an ultimate cognitive (conceptual) level. These three levels are seen as being mirrored by the unfolding of the neurological system in a predetermined orderly progression.

Figure 1

The relationship between the behavioral and neurological progression is seen as being interdependent, i.e., if the structure doesn't develop the behavior cannot, but also, if the behavior doesn't ensue, the structure may not reach its ultimate potential.

A hierarchy of development is postulated wherein each level depends upon preceding levels for its complete maturation and function. The reflex level which is seen as being completely automatic and unlearned in nature indicates the intactness of the neural structure. For example, in the absence of given reflex reactions specific impairment is predicated and learning impaired to the extent that the neural structure's deficiency plays a role



AN OPERATIONAL DIAGRAM OF THE LEVELS OF FUNCTION IN THE CNS

Figure 1

in the task involved. Such neural-structural handicaps provide an indication of expected limitations in learning which demand usually compensatory adaptation--the brain injured child is the best example of children with specific reflex level impairments.

At the next level--the perceptual level--all of the processes involved, which include the ability to transmit, imprint, recall and react to signals below the level of awareness and related meaning are developmental in nature over a period of some years--quite unlike the lower reflex level which serves only to indicate whether a system is operational or not. Behavior at this level is thought to be directly involved in the discrimination of contrasting non-meaningful units sufficient to provide an internalized monitoring system for the self-control of succeeding signals as well as the organization of outgoing motor patterns related to them. At this level the child acquires his alphabet of different sounds making up the speech of his community and later his knowledge of the orthographic forms of the printed alphabet. The level is characterized by the development of the ability to form phonemic contrasts of increasing degrees of finite character. The earliest capacities in childhood are only gross comparisons such as the sound made by the family dog and the voice of the child's mother, for example, which evolve to the more refined contrasts of the individual phonetic/phonic distinctions inherent in spoken verbal symbols. It is the development of this discriminatory ability along the auditory pathway which permits the self-monitoring of speech and its continuous self-correction. At this perceptual level not only are the discriminating features of sounds recognized but also the ability to retain each sound and recall it in the desired order. Further, the system learns to formulate the outgoing motor patterns which will be adequately imitative of the incoming signal and in the desired and expected order.

Notably, at this perceptual level, the reception of signals is differently related to each specific modality. At least, visual, auditory and tactile/kinesthetic perception are seen to have unique individualized developmental courses with no necessary relationship between them.

It is postulated that each child will show some degree of preference for one modality over the others so that one might be able to categorize children as "audile", "visile", or "tactile-kinesthetic" (Charcot in Freud, 1953) as preferred learning types.

Finally, the highest level develops, that of conceptual processing. This level--of meaning, thought, and ideas--of verbal symbolic formulation is recognizable as the level of cognition, of

of awareness, of integration. It represents all meaningful comprehension as well as all purposive verbal behavior. On its input side rapid changes in conceptualizing ability occur early in a child's development even seemingly without relation to the earlier or concurrent sensori-motor, perceptual processing development. Yet, formulation of meaningful expression, verbal or non-verbal, is seen as being intimately related to these lower developmental processes. Fulfillment, it is held, at the conceptual level can only come when the child is able to take advantage of his unconsciously acquired perceptions and through his use of the data collected through these perceptual processes increase the meaningfulness of verbal expression.

The model suggests that the perceptual level development is a necessary precursor of fulfillment of the cognitive structure because it precedes the higher level in the developmental hierarchy. Perceptual processing for children learning to learn is felt to be the essential base for all learning, especially if it is to be expressed. Once such processing of signals has developed, all of the developmental/structural/functional system for vicarious learning has been completed. (Wepman, 1964).

Tests such as the Illinois Test of Psycholinguistic Ability (ITPA, McCarthy & Kirk, 1963) based on a similar model suggested by Osgood (1963) confirm the applicability of modality distinctions and preference (Bateman, 1965). In addition, studies by DeHirsch, Jansky and Langford (1965), Sabatino (1968), Cohen (1969), Sabatino and Hayden (1970) are all illustrative of the use of batteries of tests which devote attention to modality distinctions and in most instances to the necessity for studying the perceptual processing ability of children. However, it is felt that assessment of achievement of linguistic ability or of intelligence fails to focus on the learning problem itself, but rather on what has been accomplished by the children studied based on the degree of perceptual processing ability attained at the time of the studies.

The perceptual-modality paradigm, then, is the model upon which the present study was based. The study was an in-depth longitudinal investigation over six years of the perceptual development of children as they enter the first grade and the effect that this development has on achievement in school.

While the data of the present study can be viewed independently, it was in fact a continuation of a previous study (Wepman and Morency, 1967) which undertook to explore the effects upon school achievement of such factors as the presence of an articulatory inaccuracy when schooling began and also measured verbal

intelligence at that time. An overview of preceding research which includes a study completed as a forerunner to the six-year study, in addition to the previous first three years of the present study should aid in understanding the research design and the common denominators shared by all of the studies which relate to the perceptual-modality paradigm.

The earliest of these studies (Wepman and Morency, 1963) demonstrated that speech inaccuracy in children could be etiologically identified by the pattern of errors that are made. The emphasis in this earliest study was on separating children who had developmentally determined speech inaccuracies from those whose problem was pathological. The control population N=160 which consisted of children who had not been identified by the school as having a speech problem did, in fact, show some of these children to have some speech inaccuracies. The children who were enrolled in speech therapy were tested and the greatest number of these children made errors on the same sounds as that of the control population, the major difference being that the children in speech therapy made many more errors. The pattern of inaccuracy of both groups followed the pattern of sound acquisition established by Templin (1957) and others, Poole (1934) and Reid (1947). The children with pathologic etiologies such as deafness, cleft palate, mental retardation, etc. made an identifiably different pattern of errors. That is, the errors were characteristically different (substitutions, distortions or omissions) and occurred on sounds not necessarily associated with developmental acquisition. It was hypothesized at the time of this earliest study that the children whose pattern of errors was consistent with the order of normal sound acquisition could be considered developmentally delayed rather than pathologically impaired. In accordance with this hypothesis children who evidenced a developmental slowness could still be considered age appropriate in their articulatory development and given time would improve their speech without therapy. At that time, prior to the longitudinal study, the concept of self-correction of articulatory errors was based on the assumption that as children develop finer abilities to discriminate sounds they automatically develop a self-monitoring system which serves to provide them with the necessary models for accurate speech production.

The most recent preceding study (Wepman and Morency, 1967) set out to test this possibility with confirming results. The indirect effect studied related to the development of certain necessary perceptual abilities, i.e., would children with inadequately developed auditory perception as they entered school tend

to show slower development of articulatory accuracy. The data indicated that both the amount of articulatory accuracy and the number of children demonstrating it as well as the performance on the perceptual tests became asymptotic by the end of the third grade, lending considerable credence to their being causally related in the early developmental period. One of the questions which remained in this regard and which was explored in the current study related to whether or not the experience of speech inaccuracy at the outset might have some direct or indirect effect on later learning.

In the previous study it was possible to establish a therapy/no therapy paradigm wherein those children of the total population who would have met both the school's speech therapist's criteria for acceptance into speech therapy and who showed a sufficient number of errors on an articulation test (Morency, 1962) were geographically located in two different schools. In one school all of the children meeting both criteria were given speech therapy for their speech inaccuracies, while in the other such children were, with their parents and teachers consent, withheld from therapy through the first three grades.

Again as has been reported (Morency, 1970) the two groups were indistinguishable by the end of the third grade, i.e., only a few children of either group still showed speech inaccuracy of any kind--the number in each group was essentially the same. The background of the earlier studies was provided to give a clearer picture of the longitudinal aspects of the present study.

The specific goals of the study have been to explore the relationship between

1) School achievement and early perceptual processing development.
2) School achievement and early articulatory accuracy development.
3) School achievement and verbal intelligence.
4) School achievement and speech therapy.

Methods

1. Population

One of the limitations of longitudinal research in a constricted geographical area is the attrition in the population studied. Table 1 shows this reduction in total population as well as the decreasing number of children in the experimental (speech inaccuracy) group, year by year.

Table 1

Population available at each age level

Year	1963 1	1965 2	1966 3	1967 4	1968 5	1969 6
Population N	259	208	177	151	137	120
Experimental N Population	(85) (32%)	(73) (32%)	(66) (37%)	(55) (36%)	(51) (37%)	(48) (40%)

$(\frac{85}{48} = 56\%)$*

Total population at the beginning of the first year of the study and at the end of each of the following years of the study. These periods coincide with our testing periods.

In parentheses are shown the number of children adjudged as having sufficient articulatory inaccuracy to warrant speech therapy intervention. The number of children shown at each year after year 1 are children of that group remaining in the program and the percentage of the total they represent.

*Also shown is the percentage of children in the original experimental-speech inaccurate group remaining in the program at its conclusion.

Most of the data reported hereafter relates specifically to the 120 children who were studied over the entire six grade span. Most of the data, however, relating to the first three grade accomplishments was reported in the final report of OE Project #2225 (Wepman and Morency, 1967). The population at that time was made up of 177 children. The difference in population size accounts for the discrepancies between the two studies in number of children studied at each year level. To help avoid any confusion that this discrepancy might occasion, the findings of the present study will be based on the continuing six year population both in their early perceptual abilities and their later achievement. Certain pre-study information on the population and how it was grouped is necessary for putting the present study in perspective. For example:

To explore certain aspects of the study--those relating to speech--the total beginning group (N=259) was divided initially into two groups. Based on articulatory error scores obtained by administration of the Dual Modality Test of Articulation (see Appendix A; Morency, 1962) those children with a score of five or less errors where no single sound was consistently misarticulated were considered normal (N=174) and are referred to as Group I. Those with articulatory error scores of six or more on the same test were considered as the experimental group and are referred to as Group II (N=85).

Each child in the total population was further studied by the school speech therapists and agreement as to placement within the two groups was reached without difficulty. (See Appendix B.) It was acknowledged by the therapists that under normal circumstances (when a study was not in progress) all of the children in Group II would have been enrolled in speech therapy classes.

For the purpose of studying the relative effects of speech therapy on the other variables of the study--perceptual development, school achievement and verbal intelligence--the children in Group II were further subdivided into Groups IIa and IIb. By the nature of the geographical location of the children in two public schools it was possible to designate the children in one school as that in which speech therapy was to be offered and with parental consent, the children from School II were withheld from therapy for the three years of the study. Table 2 shows the distribution of the children in the two schools at the outset of the study--grade 1--and at the conclusion of the study.

Table 2

Total Population and Experimental Group (based on speech inaccuracy) at Outset and Conclusion of Study

	Grade 1 TOTAL POPUL.	Grade 1 EXPER. POPUL.	Grade 6 TOTAL POPUL.	Grade 6 EXPER. POPUL.
School 1	N 143	Group IIa (therapy) N 47 = 33%	N 71	Group IIa (therapy) N 29 = 41%
School 2	N 116	Group IIb (no therapy) N 38 = 33%	N 49	Group IIb (no therapy) N 19 = 39%
	259	85	120	48

As can be seen, the actual number of children in the 'therapy' group was larger than those in the 'no therapy' group. They represent, however, almost identical percentages of the total population from each school. The study population was made up of every newly entered 1st grade child in two public schools. Other criteria for acceptance was based on family history and/or school personnel such as the nurse along with special examinations establishing an absence of uncorrected visual or auditory (acuity), anatomical malformations such as cleft palate, mental retardation (IQ below 90) or severe emotional disturbance. These criteria eliminated some 18 children. All of the children in the study population were white, middle-class and monolingual.

It should be borne in mind regarding the population that only those children remaining in the school system for the entire six

years of the study are reported in the findings and as has been indicated this reduced the number at the end of the sixth grade from the original 259 to 120. In the final population 29 or 62% were from the original 'therapy group' and 19 or 50% were from the 'no therapy' group. The attrition for therapy vs. no therapy groups does not reject the hypotheses that they come from the same population ($X^2 = 1.176$). If a child transferred from one school to another he was maintained for purposes of the study in his original group.

2. Data Collection

Each child was administered a battery of tests each year including:

1) Perceptual Test Battery* (see Appendix A for a complete description of the Battery)
   a. auditory discrimination sub test (Wepman, 1958)
   b. auditory memory sub test
   c. visual discrimination sub test
   d. visual memory sub test
   e. oral motor movement sub test
2) Dual Modality Test of Articulation (Morency, 1962)
3) Bender Visual Motor Gestalt Test (Bender, 1938)
4) Peabody Picture Vocabulary Test (Dunn, 1959)
5) Metropolitan Achievement Test (grade appropriate) (Durost, 1959)

All tests were individually administered with the exception of the achievement test. The first five tests are herein called the experimental Perceptual Test Battery. At the outset of the six-year study the experimental battery was administered during the first six weeks of the school year. In all other years the battery was administered during the last six weeks of the school year.

With the exception of the Auditory Discrimination sub test the experimental battery was made up of new, exploratory assessment devices which had previously been pilot tested but which had not been rigorously standardized. The Auditory Discrimination Subtest, Bender-Gestalt, (Koppitz, 1964 scoring), PPVT and the Achievement tests were all standardized forms with published norms available.

Results

The results obtained in the six-year longitudinal study will be presented in two ways. First will be shown the means and standard deviations of each of the instruments used. Second will be the significant correlations found between early (first grade) perceptual test scores and (a) later (grades 4, 5, 6) school achievement; (b) early (first grade) articulation test scores and later school achievement; (c) intelligence and school achievement and (d) early special grouping (therapy vs. no therapy) and later school achievement.

Test Battery

Table 3 shows the means and standard deviations obtained on the five sub tests of the PTB, the Articulation Test and the Bender-Gestalt scores for each of the first six grades (N = 120). Figure 2 shows the same data graphically.

Perceptual processes and school achievement

As a test of the basic hypothesis that perceptual process development effects not only speech accuracy development (as demonstrated in OE Project #2225) but might also serve as a predictor of later school accomplishment, a correlational matrix between early (Grade 1) experimental battery scores and later (grades 4, 5, 6) school achievement scores were derived. Tables 4, 5, and 6 show the statistically significant correlations at each of the three grades. The data on each table are grouped showing the significant correlations between 1st grade PTB scores and MAT scores at each grade level for the total population N = 120.

Speech Inaccuracy

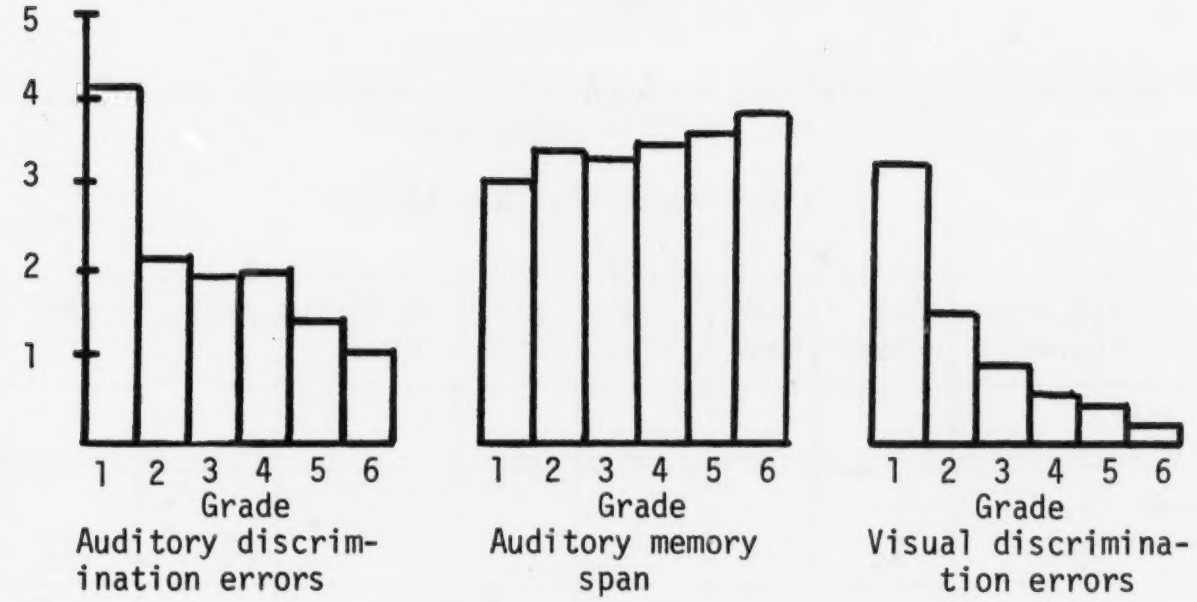
The second area of interest in the study related to the articulatory ability of the children. Using the Dual Modality Test of Articulation (Morency, 1962) wherein a child responds to 42 pictures and imitates 44 spoken words covering 22 phonemes in the initial pronunciation position an error score was derived for each child. For the purpose of studying the effect of therapy the total population was subdivided into those whose scores were five or less (normal) and six or more (abnormal). The latter group was subdivided into therapy vs. no therapy groups. (See section on population for a more complete discussion of this grouping.) Figure 3 shows the mean articulatory errors made by each of the groups--total, experimental Group IIa (therapy) and experimental Group IIb (no therapy) throughout the six years of the study.

Table 3

PTB, Articulation Test and Bender Gestalt Mean Scores

(N = 120)

Mean Age (SD=3 mo.)	6-3 Grade 1		7-11 Grade 2		8-10 Grade 3		9-10 Grade 4		10-10 Grade 5		-10 Grade 6	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Auditory Disc. (error score)	4.16	4.14	2.15	1.75	1.99	2.53	2.00	2.4	1.45	2.20	1.05	1.12
Auditory Memory (span)	3.02	.87	3.33	.79	3.29	.81	3.49	.78	3.64	.82	3.83	.85
Visual Memory (error)	4.69	1.65	3.07	1.75	1.89	1.34	1.41	1.22	1.13	1.08	.67	.82
Visual Disc. (error)	3.23	1.72	1.56	1.47	.90	.99	.62	.94	.46	.66	.23	.49
M. Movement (span)	5.00	1.51	6.51	1.85	7.23	1.32	7.89	1.38	8.44	1.47	9.34	1.50
Articulation (error)	5.60	6.0	1.50	2.82	.70	1.84	.67	1.58	.31	1.09	.25	1.03
Bender-Gestalt (error-Koppitz)	7.64	2.97	3.17	2.20	1.85	1.70			1.07	1.41	0.34	0.76



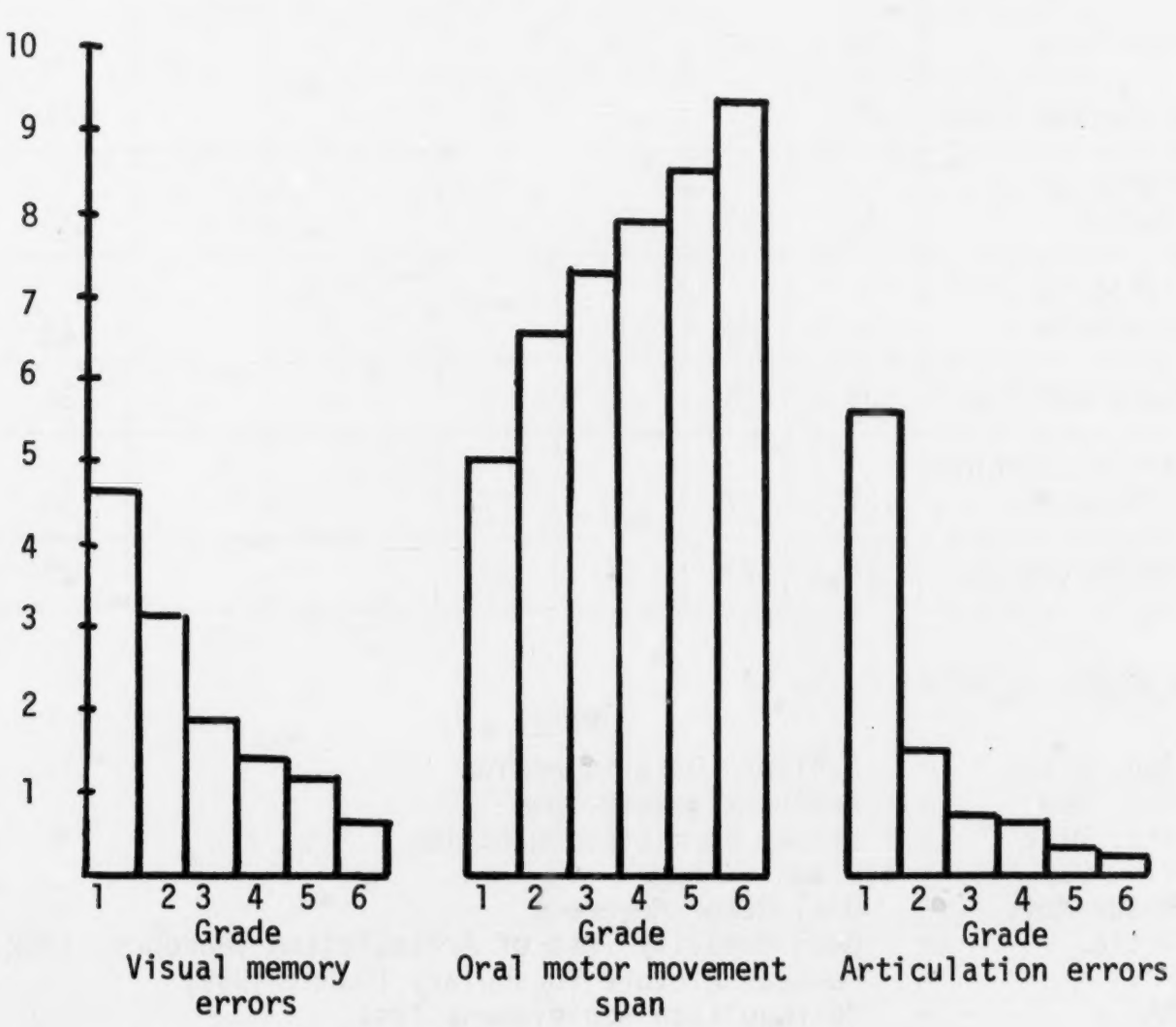


Fig. 2--Mean articulation and perceptual test scores (N=120).

Table 4

Significant Correlations between 1st Year Perceptual Processes and 4th Year Achievement

Total Population N = 120

1st Year scores	Aud. Disc.	Aud. Mem.	Vis. Disc.	Vis. Mem.	Motor* Mov.	Artic.	PPVT	B-G
MAT's								
Word Knowledge	.29	.23	.26			.21	.47	.34
Reading	.28	.23	.25				.33	.29
Spelling	.34	.23	.22				.47	.33
Language Usage	.21	.24	.23	.21			.21	.35
Parts of Speech	.32	.21	.26	.20			.38	.47
Punct. & Capitals	.34	.25	.21				.28	.23
Language Total	.38	.26	.26				.36	.38
Arith.Concepts & Problems	.25	.27	.29	.27			.33	.49
Arith.Comput.	.24	.21	.31	.29			.29	.37

Legend - (Tables 4, 5, 6)

Tests

Aud. Disc. = Auditory Discrimination
Aud. Mem. = Auditory Memory Span
Vis. Disc. = Visual Form Discrimination
Vis. Mem. = Visual Memory
Motor Mov. = Oral Motor Movement
Artic. = Dual Modality Test of Articulation (Morency, 1962)
PPVT = Peabody Picture Vocabulary (Dunn, 1959)
MAT = Metropolitan Achievement Test
B-G = Visual Motor Gestalt Test (Bender, 1938) (Koppitz, 1964)

*no significant correlations
underline - at .01%
no underline - at .05%

Table 5

Significant Correlations between 1st Year Perceptual Processes and 5th Year Achievement

Total Population N = 120

1st Year scores	Aud. Disc.	Aud. Mem.	Vis. Disc.	Vis. Mem.	Motor* Mov.	Artic.*	PPVT	B-G
MAT's								
Word Knowledge	.29		.18	.20			.53	.32
Reading	.20	.25	.24				.50	.34
Spelling	.23	.25	.20	.26			.29	.35
Language Usage	.30	.24	.25	.24			.25	.36
Parts of Speech*								
Punct. & Capitals	.22	.33		.20			.36	.40
Language Total	.25	.29	.19	.24			.33	.38
Language Study Skills	.18	.30	.19	.23			.34	.39
Arith.Concepts & Problems	.33	.27	.26	.32			.27	.36
Arith. Comput.				.31				.37

Legend-see Table 4

*no significant correlations
underline - at .01%
no underline - at .05%

Table 6

Significant Correlations between 1st Year Perceptual Processes and 6th Year Achievement

Total Population N = 120

1st Year scores	Aud. Disc.	Aud. Mem.	Vis. Disc.	Vis. Mem.	Motor* Mov.	Artic.*	PPVT	B-G
MAT's								
Word Knowledge	.27	.25	.22				.48	.36
Reading	.26	.23	.22				.46	.43
Spelling		.20		.22			.19	.37
Language Usage	.28	.22	.22	.20			.28	.39
Parts of Speech								.20
Punct. & Capitals	.19	.33	.22	.18			.24	.28
Language Total	.27	.32	.28	.24			.28	.35
Language Study Skills		.22		.21			.35	.46
Arith. Concepts & Problems		.23	.33	.28			.22	.38
Arith. Comput.		.26	.23	.31				.32

Legend-see Table 4

*no significant correlations
underline - at .01%
no underline - at .05%

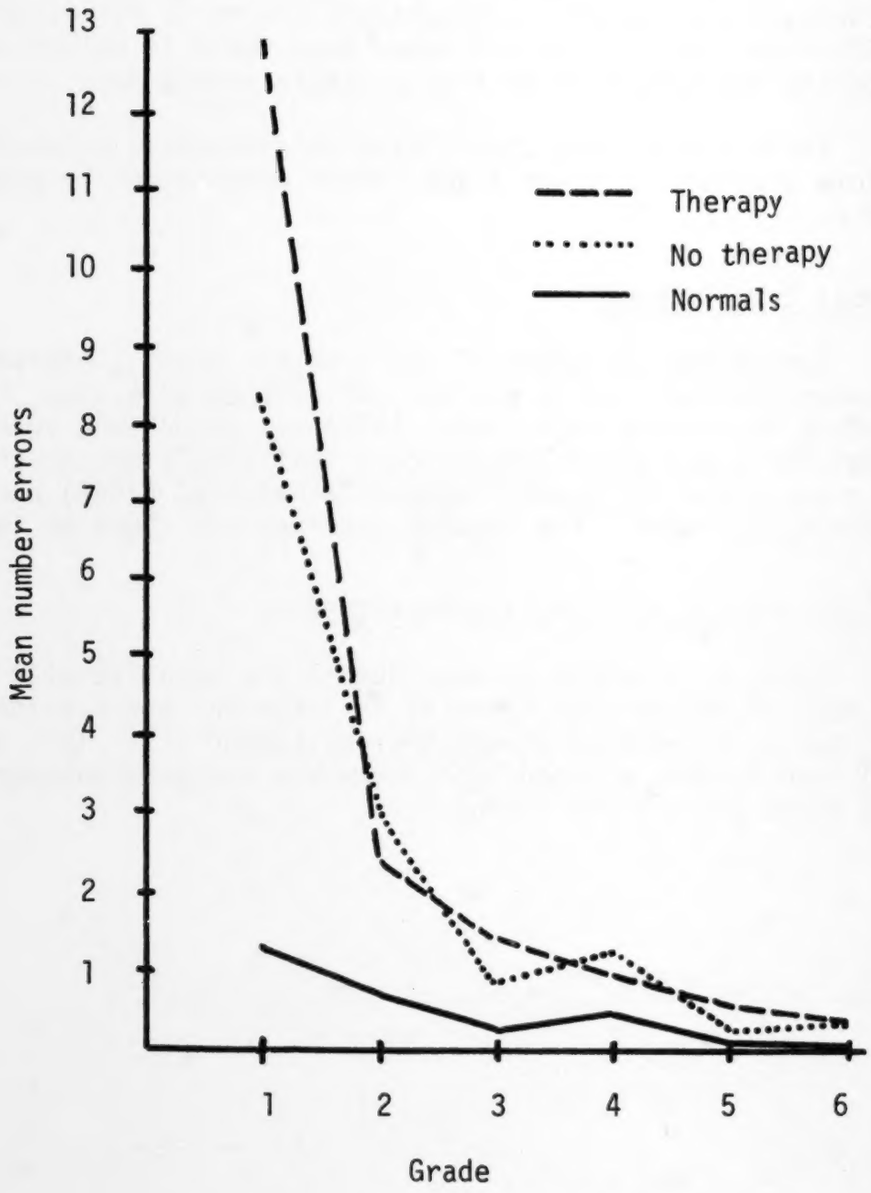


Fig. 3--Mean articulation error scores for normal, therapy and no-therapy groups through six years.

An analysis of variance was run between the experimental groups on achievement. To control for any possible effects of the initial differences in articulation errors, an analysis of covariance was run with articulation errors as covariate (Bock, 1963; Finn, 1967). Table 7 shows that there is evidence for considering the groups to be from a single normal population.

Table 8 shows the significant relationships between articulatory accuracy in grade 1 and school achievement in grades 4, 5, and 6.

Verbal Intelligence

During the six years of the over-all study, three different standard devices for assessing intelligence were used, the Peabody Picture Vocabulary Test (Dunn, 1959) was given each year, the Lorge-Thorndike Group Intelligence Test (1957) was given in years 1, 3 and 5 and the Raven Progressive Matrices (1958) were given in years 4, 5, and 6. The results obtained are shown on Table 9.

Speech therapy and school achievement

Table 10 presents in some detail the relative mean achievement on each of the MAT sub tests of children who had previously been grouped as in need of speech therapy (Group II). This grouping had been further divided into those who received therapy (Group IIa) and those who did not (Group IIb).

Table 7

Analyses of Variance and Covariance of Therapy vs.
No Therapy by Grade Level

Analysis of variance

	df	Multivariate F	P less than
A. Achievement--Grades (4,5,6)	12	3.958	.0001
B. Therapy vs. no therapy	1	.842	.567
A x B interaction	2	.8867	.5852
within cell error	138		

(2 x 3 multivariate ANOVA = 8 dependent variables -- proportional n orthogonal case)

Analysis of covariance

Covarying on year one articulatory errors

(2 x 3 multivariate ANOVA - 8 dependent variables -- 1 covariate, proportional n orthogonal case)

	df	Multivariate F	P less than
A. Grades 4,5,6	2	3.9333	.0001
B. Therapy vs. no therapy	1	.503	.852
A x B interaction	2	.911	.557
within cell error	137		

Thus, in both analyses, interaction between groups and grades is negligible. There is a strong developmental trend in achievement, but there is no evidence to reject the hypothesis that the achievement scores of the therapy and no therapy groups are sampled from a single multivariate normal population.

Table 8

Significant Correlations between Normal and Experimental Groups
1st Year Articulation and 4th, 5th, 6th Year Achievement*

1st Year	Year 4		Year 5		Year 6	
	I	II	I	II	I	II
Word Knowledge		.32				
Reading		.32				
Spelling		.31	.29	.32	.37	
Language Usage	.30	.37				
Parts of Speech	.31					
Punctuation & Capitals			.26			
Language Total	.23					
Language Study Skills						.32
Arithmetic Concepts & Problems	.23					
Arithmetic Computation	.23					

*Metropolitan Achievement Test

Table 9

Mean IQ's and Percentiles at Various Grade Levels

N = 120

	1	2	3	4	5	6
Peabody IQ	107.35	108.73	108.05	110.40	106.95	112.72
Lorge-Thorndike IQ	114.48	-	109.28	-	110.52	-
Ravens (Percentiles)	-	-	-	68%	70%	70%

The Peabody IQ's were used to ascertain that the population continued to meet the 'normal' criteria and as a constant against which comparisons with achievement and perceptual ability could be made. The L-T and The Ravens Progressive Matrices were used as confirming information relative to general intelligence. The results of both these additional tests as indicated on Table show a close relationship between all of the intellectual measures.

Table 10

MEANS & S.D.'s (Standard Scores) of the 2 Experimental Groups on the Metropolitan Achievement Test--Years 4, 5, & 6

Group IIa N=29
Group IIb N=19

	Year 4		Year 5		Year 6	
			Word Knowledge			
	(20-75)**		(20-80)**		(20-80)**	
	Mean	SD	Mean	SD	Mean	SD
Group IIa	56.93	8.46	50.89	9.30	56.03	9.14
Group IIb	58.84	5.20	51.53	7.46	56.58	7.49
			Word Discrimination*			
	(19-72)**					
	Mean	SD	Mean	SD	Mean	SD
Group IIa	58.07	7.76				
Group IIb	59.05	6.86				
			Reading			
	(19-75)**		(18-80)**		(18-80)**	
	Mean	SD	Mean	SD	Mean	SD
Group IIa	55.96	9.9	49.07	8.72	51.55	9.41
Group IIb	56.63	8.80	49.05	9.28	55.42	9.41
			Spelling			
	(29-71)**		(21-80)**		(21-80)**	
	Mean	SD	Mean	SD	Mean	SD
Group IIa	62.21	7.8	52.36	8.70	57.52	9.61
Group IIb	63.47	6.21	52.68	8.25	60.79	6.57

*Subtest appears in 5th, 6th year achievement test battery only
**Possible range

Table 10 cont'd

	Year 4		Year 5		Year 6	
			Language Usage			
	(24-80)**		(19-86)**		(19-86)**	
	Mean	SD	Mean	SD	Mean	SD
Group IIa	56.79	7.9	49.39	7.99	54.17	9.03
Group IIb	59.10	7.46	51.21	7.68	55.89	7.53
			Parts of Speech*			
			(34-72)**		(34-72)**	
			Mean	SD	Mean	SD
Group IIa			54.50	12.90	56.41	9.96
Group IIb			51.21	9.02	57.05	16.83
			Punctuation & Capitals			
	(25-77)**		(21-80)**		(21-80)**	
	Mean	SD	Mean	SD	Mean	SD
Group IIa	60.94	6.84	48.79	10.06	54.14	10.77
Group IIb	60.26	7.04	49.47	8.91	53.95	10.60
			Language Total			
	(20-85)**		(21-84)**		(21-84)**	
	Mean	SD	Mean	SD	Mean	SD
Group IIa	60.96	7.2	50.32	9.32	55.83	8.75
Group IIb	61.79	8.03	50.63	8.95	57.16	9.78

*Subtest appears in 5th, 6th year achievement test battery only
**Possible range

30

Table 10 cont'd

	Year 4		Year 5		Year 6	
			Language Study Skill*			
			(26-80)**		(26-80)**	
			Mean	SD	Mean	SD
Group IIa			51.32	10.85	56.03	11.37
Group IIb			48.68	9.70	55.48	10.70
			Arithmetic Concepts & Problems			
	(20-80)**		(17-79)**		(17-79)**	
	Mean	SD	Mean	SD	Mean	SD
Group IIa	57.64	9.46	47.71	9.13	53.38	9.35
Group IIb	57.16	8.77	49.63	9.39	54.26	9.27
			Arithmetic Computation			
	(21-81)**		(23-84)**		(23-84)**	
	Mean	SD	Mean	SD	Mean	SD
Group IIa	63.60	10.25	46.11	8.99	55.90	12.41
Group IIb	62.10	11.58	46.21	5.18	56.16	12.76

*Subtest appears in the 5th, 6th year achievement test battery only
**Possible range

Analysis and Discussion

Introduction

The present study and its predecessor (Wepman and Morency, 1967) undertook to explore by means of a newly developed perceptual test battery the levels of perceptual processing ability achieved by children at the outset of formal schooling; the relationship between these readiness factors for learning and articulation accuracy, verbal intelligence and school achievement as assessed by (1) the Dual Modality Test of Articulation, (2) The Peabody Picture Vocabulary Test and (3) the Metropolitan Achievement Test, respectively. While the present report relates most specifically to the findings of the relationships between early (grade 1) perceptual processing ability and school achievement, verbal intelligence and speech in grades 4, 5, and 6 some of the data will be included from the previous study on the same population during grades 1, 2, and 3.

The major thrust of the earlier study was toward an explication of the relationships of perceptual processing ability to speech accuracy and to speech therapy and the relationship of both to school achievement. The central point of interest in the present study was on the role of early perceptual processing and the more advanced educational achievement of children after, as was shown, the perceptual processing ability had completed its development.

Secondary interests in the effect of speech therapy on achievement and the relationship of the developmental changes which occur to verbal intelligence are also explored.

Instrumentation

The study established achievement norms (means and standard deviations) for each of the sub tests of the PTB; articulation and visuo-motor ability. Each of these showed the expected changes over time. The perceptual processes became relatively asymptotic after the third grade, developmental articulation errors occurred with less than a .01% frequency; oral motor movement increased as the oral structures (lips and tongue) continued to improve in their capacity to perform continuing movements.

As predicted in the theoretical construct of the perceptual-conceptual, modality-bound model, the child regardless of any initial lags in specific modality function at the outset of school

(roughly age 6) develops the capacity to utilize his perceptual discriminations and recall by the time he reaches his ninth birthday. Improvements beyond that time are minimal and are felt to be adaptive. Some few children, it is true, never do catch up. They never reach adequacy in one or the other of the perceptual modalities. For these few children compensatory use of their better modality seems essential. For those children who do attain adequacy by nine years, however, either modality becomes useful. If the lag in development is greater along a single modality and in all of its parts (discrimination and recall in the present battery extended to include orientation and sequencing in later versions), the chances are that a modality imbalance will remain and the slower developing modality will never become the modality of choice for the child. Thus, a visual perceptual lag in development may indicate a constant use of and selection of the auditory mode in learning and vice versa.

Perceptual Processing and School Achievement

The data quite clearly establishes that early perceptual processing ability has a limited but significant predictive value for later school achievement.

It is instructive to note that significant relationships between three of the five sub tests (Auditory Discrimination and Memory and Visual Discrimination) and all nine of the MAT sub tests are present at the 4th grade level. The fourth sub test (visual memory) retains a significant correlation with four of the nine--namely Language Usage, Part of Speech and the Arithmetic sub tests. Motor movement, however, loses any relationship as would be expected since it had previously been established that this perceptual ability related to speech accuracy and by the fourth grade almost no developmental articulatory problems existed. Visuo-motor ability, however, because of its high visual content,retains a significant relationship.

To continue in this specific vein Table 5 shows literally the same condition holding although the prediction is in some instances made with a lesser degree of confidence. It should be noted, however, that the least predictive visual memory factor at grade 4 becomes highly predictive of each of the MAT sub tests at grade 5. Reading and computation apparently call forth a need for visual memory at this level just as they do for auditory discrimination and memory and visual discrimination and visuo-motor ability.

Children with a poor perceptual start continue to feel its effects even though their perceptual abilities have developed. By grade 6 when reading is firmly established the relationships are

still present but less evident. Auditory discrimination in fact is seen to relate mostly to reading but no longer seems predictive of numerical conceptual learning. Considering the task--auditorially monitoring sounds--which can logically relate to verbal learning has a decreasing relationship to that part of computation which is purely numerical. By the sixth grade from the present data, it would appear that such verbally important distinctions as the ability to discriminate are no longer operable.

In general, then, the study shows the importance of early development of perceptual processing. Lags in development are seen to have a continuing relationship to school achievement throughout the elementary grades although the perceptual abilities reach their developmental crest by the end of the third grade and are asymptotic thereafter.

The significance of this factor to education lies in the demonstration of the value of perceptual process assessment as early in the educational career of each child as possible. By early identification supportive or compensatory adjustment may be possible in the curricular offerings to those children who show marked imbalance in modality dominance offsetting the lag in development. Future research should establish the values of specific training in the deficient modalities versus emphasis on utilizing the better developed modality in the initial stages of learning or a combination of the two approaches.

Speech Accuracy and Achievement

Following our initial interest in the possible effects of beginning school with developmental articulatory inaccuracy and school achievement the design of the study permitted the exploration to continue through the upper grades. At the fourth grade level a few significant correlations continued to exist especially relating to aspects of acquiring the skill of reading and spelling. These had almost entirely disappeared by the fifth grade and sixth grade except for learning to spell which retained a relationship of some proportions throughout.

Thus, by this time in a child's school career whether he began school with a speech problem did not materially effect his accomplishment in learning to read although it did have some continuing effect on his learning to spell. The degree of relationship to the latter seems important to recognize for those children concerned. Articulatory accuracy was seen to be achieved by literally all but 1% of the children by the end of the third grade

and while some mild effect was seen on fourth grade reading, only learning to spell remained consistently related. At least one interpretation of these findings would be that both articulation accuracy and spelling ability are related causally to the acquisition of perceptual processing. As perceptual discrimination and memory are acquired, their ability to monitor speech increases and articulation becomes more accurately produced. Only some time later in development, however, is the child able to utilize his perceptual capacities for the task of spelling and in fact may always show a weakness in this regard--poor auditorizers as well as poor visualizers have difficulty in the phonic interrelationships that underlie spelling, since that process requires facility with both perceptual modalities.

Children with lags in articulation development, therefore, might well be in need of special instruction in spelling regardless of the level of their perceptual processing.

School Achievement and Verbal Intelligence

While verbal intelligence was not a specific dependent variable of the study, assessment of the children's intellectual ability was made each year to be certain the population continued to meet the criteria of normal intelligence. The data shows a mild but significant relationship to exist throughout and was given due consideration in establishing the other findings of the study by regression analysis. The low but positive relationship is an expected one. Brighter children do somewhat better in school than the less bright. Of some interest is the consistency of PPVT IQ's over all six years of the study as well as the confirmation by other assessment obtained during the later years by non-verbal test data (Progressive Matrices). The population appears to be a consistent one, stable in their cognitive abilities and achieving in school in keeping with their intellectual ability.

While not a specific measure of intellectual ability the Bender Visuo-Motor Gestalt Test is noted to have well-developed developmental standards when the Koppitz (1964) scoring method is applied. Confirmation of the developmental aspect of this test is found in the data. A continuing relationship throughout each year of the study is found between the B/G results and school achievement. This test apparently measures beyond simple visual and motor capacity certain intellectual factors related to achievement. These appear to be in the cognitive realm since the test results also relate to the specific intellectual measures.

From this data it would appear that both verbal intelligence and visuo-motor development enter the complex of capacities necessary for achievement. When these are added to the level of perceptual processing ability in both visual and auditory modes, a somewhat clearer picture is obtained of some of the necessary non-linguistic parameters of early childhood learning.

School Achievement and Speech Therapy

As discussed earlier the preceding study centered on the effect of providing speech therapy for children who showed a sufficient degree of speech inaccuracy to warrant intervention by speech therapists. By a split population design one group of such children were given therapy and one group withheld from therapy during the first three years of the study. As has been noted, no difference in articulation appeared between the two groups by the end of the third grade.

The present study provided the opportunity, however, of gauging whether having such therapy might not influence the child's ability to learn. The evidence seems quite clear. When accomplishment in school achievement was assessed at the upper elementary grades of the present study literally no distinctions between groups were obtained; in fact, in most subtests the means and standard deviations were identical. The only inference that can be drawn from this seems self-evident--there is no discernible value in terms of later school accomplishment accruing to children as the result of their having had speech therapy.

Conclusions

The major findings of the study were:

(1) The Perceptual Tests show a yearly change characteristic of developmental processes;
(2) Perceptual process ability and articulation errors become asymptotic by the end of the third grade;
(3) There is no discernible difference in articulation accuracy whether or not a child is exposed to speech therapy during the first three grades;
(4) There is a continuing effect upon school achievement of the level of perceptual processing ability at grade 1;
(5) There is almost no discernible relationship between early articulation ability and school achievement at any grade level;
(6) Speech therapy did not enhance the school achievement of those children who were exposed to it over those who were not.

The study appears to have confirmed certain factors about learning; the role of perceptual processes can be seen in a clearly defined way. The stage of readiness in the basic perceptual processes with which a child enters school has an effect on his learning not only during the rapid developmental period up to grade 4 (to age 9) but continuing thereafter through his 6th grade or 12th year. This of course argues for the early discovery and identification of children at the nether end of specific sensory modality distributions. However, the disposition of these children to maximize their potential is still open. Two of the questions which are immediately brought into focus in considering such problems revolve around whether or not there is value in 1) perceptual training in the early years to attempt to offset lags in development, 2) adjusting the methodology of teaching new grade-level material to correspond to and utilize a child's best developed modality for learning. Both of these questions certainly hold strong implications for educators and seem to point to a useful next step in research.

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Appendix A: Description of Tests

Appendix B: Reliability and Validity

Appendix C: Special Reference List

Appendix A

THE TEST BATTERY

This section discusses each of the tests used in the study. The tests of intelligence, vocabulary, auditory discrimination, visuo-motor gestalt, reading readiness and school achievement are standard forms. The reliability and validity of each is quoted from the test manuals. The additional tests of perceptual function are being presently standardized by the Speech and Language Research Laboratory. Wherever reliability and validity data is available it is presented; for the most part, however, such data is not yet in a condition suitable for presentation.

The tests are presented in the following order:

Intelligence
- Lorge-Thorndike Intelligence Test*
- Raven Progressive Matrices - Coloured and Standard*

Vocabulary
- Peabody Picture Vocabulary Test*

School Achievement
- Metropolitan Achievement Test*

Articulation
- Dual Modality Test of Articulation**

Perceptual
- Auditory Discrimination Test*
- Auditory Memory Test**
- Visual Perception Tests** (Discrimination and Memory)
- Oral Motor Movement**
- Visuo-Motor Gestalt (Bender)* (Koppitz Scoring)

*Standard form
**Experimental form

The Lorge-Thorndike Intelligence Test

The Lorge-Thorndike Intelligence Test (28) is a group test which yields IQ equivalents, grade percentiles and grade equivalents. Individual Level 3 is appropriate for grade 5 and utilizes test materials that are both verbal and non-verbal in character. The Battery forms are power tests rather than speed tests.

The Raven Progressive Matrices
Coloured and Standard

The Progressive Matrices is a test of a person's capacity to apprehend meaningless figures -- see the relations between them, conceive the nature of the figure completing each system of relations presented and by so doing, develop a systematic method of working. The author cautions against considering this test, by itself, a test of "general intelligence". It was used in this study as a contrast to the Peabody Picture Vocabulary Test.

The coloured matrices (used in this study in the 4th grade) is for use with young children and old people, for anthropological studies and for clinical work. The standard matrices can be used for all ages.

The Peabody Picture Vocabulary Test

The Peabody Picture Vocabulary Test (14) is designed to provide an estimate of a subject's verbal intelligence through measuring his hearing vocabulary. The test is appropriate for subjects 2 years 6 months to 18 years. No oral or reading ability is required. The test yields IQ, percentile equivalents, and MA scores. It was administered individually in this study, though group testings are possible. The subject is required in some manner, usually by pointing, to indicate his choice from four pictures presented which picture goes with the word the examiner has presented orally. The only equipment needed is the published series of plates and scoring forms for each subject. There are two equivalent forms, A and B.

The manual for the PPVT reports the test has correlated highly with other well-established measures of intelligence. Cited as examples are the Revised Stanford-Binet Tests of Intelligence, the Revised Van Alsteyne Picture Vocabulary Test and the Revised Columbia Mental Maturity Studies. Reliability data for the PPVT has indicated that the two forms of the test are highly correlated for all age levels of normal, mentally retarded and cerebral palsied subjects. No evidence for test-retest or long term reliability was cited by the author of the PPVT.

There are 150 items on the entire test. However, by the establishment of a basal and ceiling it is necessary to administer only a segment of the total test.

Originally, this test was planned to be the primary source of intelligence data of the population of this study. Subsequent work

with the PPVT has led to questions regarding its validity and to some extent its reliability (25, 33, 34). The PPVT thus was included in this report in order to further assess its usefulness in light of reported inconsistent data.

The Metropolitan Achievement Tests

The Metropolitan Achievement Test (15) is designed to be a coordinated series of measures of achievement in the important skill and content areas of the elementary and junior high school curriculum. It has five levels or batteries, two of which were used in this study---the Elementary Battery Form B and the Intermediate Battery (partial) Form Am. The tests' content of the various batteries is designed to tap the most important knowledge or skill areas of the grade (s) for which a particular level is intended. Each level yields standard scores, percentile ranks and grade level equivalents. Repeated extensive standardization studies, using over 200 school system populations, have provided the normative data. Split-half reliability coefficients show a median r, range of .80-.94 for sub tests of the first three batteries.

The Dual Modality Test of Articulation (Morency)

The Dual Modality Test of Articulation was designed to demonstrate for the examiner a particular child's articulatory proficiency on initial consonant sounds in relation to his growth level in the developmental sequence of acquiring sounds (30). This is accomplished by listing the sounds that are being examined on a recording sheet in the order that 75 per cent of the children in Templin's study (45) properly articulated the sounds tested in the initial position.

The test consists of two parts; one part of the test uses visual stimuli and the other uses auditory stimuli. In the visual section, the subject is shown pictures and asked to name them. Two pictures are given for each sound. In the auditory section of the test, the subject is instructed to repeat stimulus words after the examiner. There are two words for each sound. In the auditory part of the test, the subject is instructed to look away from the examiner. The words themselves are non-substantive and have little direct visual correlates. There are four opportunities to test each initial consonant.

The test yields error scores. In addition, because the sounds are listed in a developmentally acquired order, it is possible, by inspection of the profile of errors that are recorded, to interpret

the nature of the articulation inaccuracy. That is, the determination of a developmental versus an organically based pathological articulation inaccuracy can be at least initially made by the location of errors on the recording form. A clustering of errors toward the end of the test, and particularly in the last 10 sounds on the test would tend to indicate a developmental articulatory inaccuracy.

Auditory Discrimination Test (Wepman)

The Wepman Auditory Discrimination Test is designed to assess a child's ability to recognize the fine differences between phonemes used in English speech. Two equated forms of the test are available. The test is generally appropriate for children beginning at age 5. No visual, speech or reading ability is required to take the test. The test is administered individually, is untimed and takes only a few minutes The child is asked to listen to selected words read aloud to him. He is then asked to make only one decision--are the two words exactly alike or are they different? He responds any way he chooses--just so the examiner understands his intention. Each form of the test consists of 30 pairs of monosyllabic words, differing in a single phoneme in each pair, and 10 word-pairs, which do not differ at all. The contrasting phonemes in each word-pair are always in the same position, i.e., initial, medial or final.

Reliability measured by test-retest administration (N = 109), as reported in the manual, was + .91. Reported in the literature are many studies that show auditory discrimination, as assessed by the Wepman Auditory Discrimination Test, to be related to the development of speech accuracy and reading ability. (See Appendix C for list of studies using this test.)

The Auditory Memory Test

The Auditory Memory Test was developed for and first administered to a large group in the present study. The present study, it is expected, will provide the initial normative data. The test is intended to be a measure of immediate recall of English phonemes (nonsense syllables). It can be administered in a few minutes. The units that are used consist of the /ē/ preceded randomly by one of the eight consonants that are acquired early in children's speech (31, 45). The test begins with two units and increases through eight units. There are two trials at each level. The second trial for each level need not be given if the first trial was successful. The test continues until the subject fails to recall both trials on the same level, or, of course, to the successful completion of the eight unit level.

The score is the number of units in the longest series correctly reproduced by the child.

Test of Visual Perception

The Tests of Visual Perceptual Ability consist of tasks utilizing visual memory and visual discrimination. The stimulus figures are the nine Wertheimer (59) geometric figures that were adapted by Bender for her Visual Motor Gestalt Test (3). The tests are multiple choice in form and therefore motoric facility is not required to take the test. In the memory task, the test item is exposed for 5 seconds and then removed. A sheet with four designs--the original one and three erroneous ones--was then exposed and the child was asked to indicate the correct design. In the matching task, both sheets are exposed simultaneously--the sheet with the original design and the sheet with the original design and three erroneous ones. The child is asked to point to the drawing on the four design sheet that is identical with the drawing on the other sheet. The memory task is necessarily always presented first.

The Oral Motor Movement Test

The Oral Motor Movement Test is a modification of a known clinical tool. The present study is one of its first large-scale uses. Standardization data are largely forthcoming and unpublished at the present time. This test was included in the study to facilitate an analysis of articulation inaccuracies. It is designed to be a measure of motor facility in the physical speech mechanisms. The test is simple, requires no apparatus other than a stopwatch and takes only a few minutes to administer. The subject is first asked to repeat the sounds "pa", "ta", and "ka" individually then in rapid sequence. He is then asked to put the sounds together in the nonsense word "pataka" and repeat this rapidly. The same procedure is used with two other verbal formulations "put take" and "bad dog" though in these instances no practice period is involved. The number of repetitions of each task per 5 second period is recorded and the average of these becomes the score.

Visual Motor Gestalt Test (Bender)

The Bender Visual Motor Gestalt Test (2) is a clinical test found to be useful in assessing and describing a wide range of psychological and organic pathologies. It also has been found to relate well to school achievement in the early school years and to

intelligence in children (27). The test consists of nine designs which are presented one at a time and which the subject is asked to copy on a blank sheet of paper. The administration of the test is fundamentally individual though one examiner can observe small (3 or 4) groups taking the test after individual instructions and designs have been presented. The test takes only a few minutes to administer.

A fairly voluminous body of research relevant to the Bender Gestalt Test has emerged since the test's origin in 1938. A large part of this research has dealt with children's protocols and developmental aspects of the visual motor task. Koppitz (27) has devised an objective scoring system for the Bender test when used with young children. The Koppitz scoring system was employed in the present study. Koppitz also has determined age norms for normal school children. She has shown the test to be relevant to school achievement, emotional disturbance, brain injury and mental retardation.

Reliability in a test-retest situation yielded statistically significant chi-squares for nine out of twelve groups (6-8 years in age).

Appendix B

RELIABILITY AND VALIDITY

The Experimental Test Battery made up of five subtests, Auditory Discrimination, Auditory Memory, Visual Discrimination and Visual Memory and Oral Motor Movement had with only one exception not been previously standardized. Figure 2 and Table 3 show explicitly the developmental (change over age) nature of each of the tests used, including the articulation test and Bender-Gestalt.

The apparent extended improvement between grades 1 and 2 relates for the most part to the fact that the time span between 1 and 2 was 18 months (grade 1 at outset of year and grade 2 at end of year). The more regular progression after grade 2 seems related to the twelve month period. It probably is true, however, that children make their greatest gains over-all in the age-time period of grades 1 and 2 which approximates ages 6 and 7. The relatively small differences (statistically non-significant) after the third grade indicates that the upper level of developmental change in perceptual processing occurs at or just before the ninth birthday. Changes beyond that time are seen as adaptive improvements in sensory processing rather than continued development for all but a few children who are markedly delayed in specific modalities.

Reliability

The reliability data on the three subtests of the battery where the split-half formula was appropriate are relatively good indicating some degree of confidence can be placed on their use. Because each of the tests given involved new experiences for the children, it was felt that reliability estimates for the auditory span test, and the oral motor movement test by a test-retest formula would not be feasible. The effect of practice and the noted improvements over time obviated this approach. However, the longitudinal nature of the study providing year by year experience with the instrument showed relatively stable changes over time in the expected direction and to the expected degree.

Split-half correlations using the Spearman-Brown formula obtained on certain subtests of the PTB where appropriate on the 1st grade population were (N=259):

Auditory Discrimination = r = .89
Visual Memory = r = .61
Visual Discrimination = r = .56

Validity

The articulation test used had been previously standardized for clinical use (Morency, 1962). The present study provided an opportunity however for further adding to our knowledge of its validity.

An estimate of the validity of the test was obtained by comparing the number of children who were tested and felt to be in need of therapy by the school district's speech therapists with the number of children assigned to the experimental (speech inaccuracy) group by using the five error cut-off point discussed earlier.

These results can be summarized in the following manner:

Table 11

Therapist	Needs	Does not Need
Test-need	44	4
Test-not need	2	70

A correlation of .916 is obtained as a systematic underestimate of the tetrachoric validity coefficient $r_t > .95$ (Quinn, McNemar, p.198, Chesire, Saffir, Thurstone, Computing diagrams for the tetrachoric correlation, University of Chicago Press, 1933). The test, therefore, seems to measure quite accurately the same condition that speech therapists judge in their evaluation of children in need of therapy.

Appendix C

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